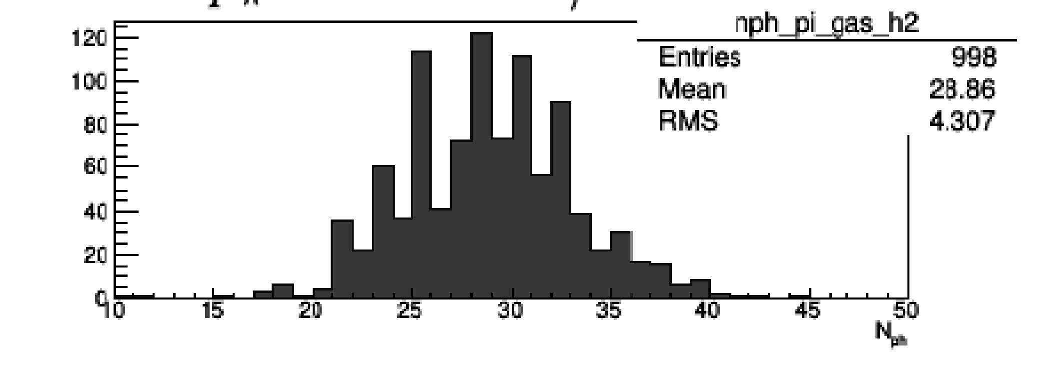
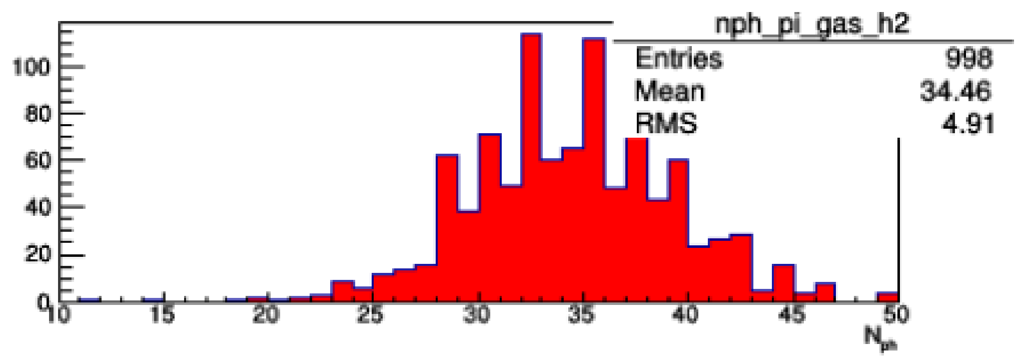
Dual-radiator RICH: update

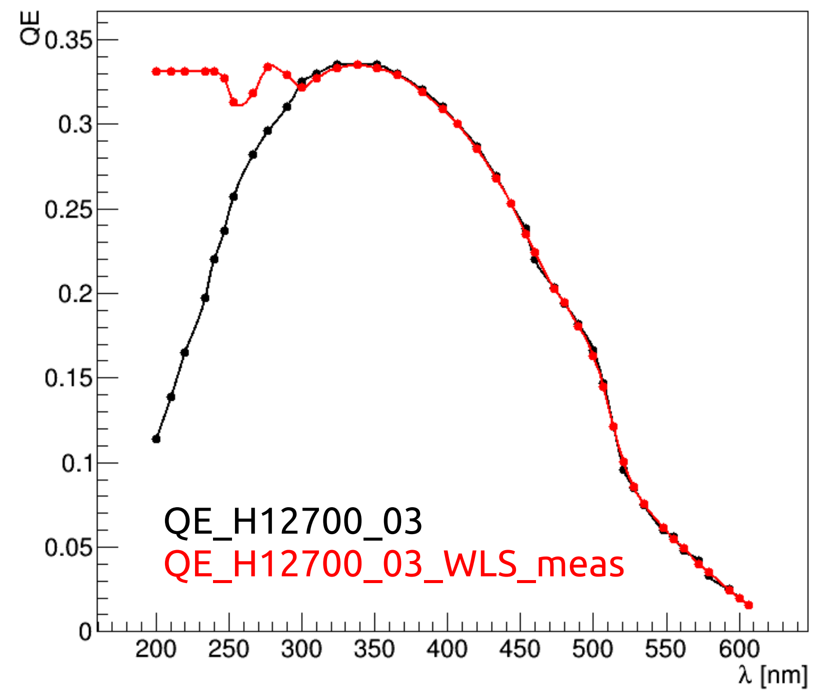
Alessio Del Dotto for the EIC PID/RICH collaboration
February 13, 2017

Number of p.e. for the gas – C_2F_6 (n = 1.00086)

$$p_\pi = 31\ GeV/c$$



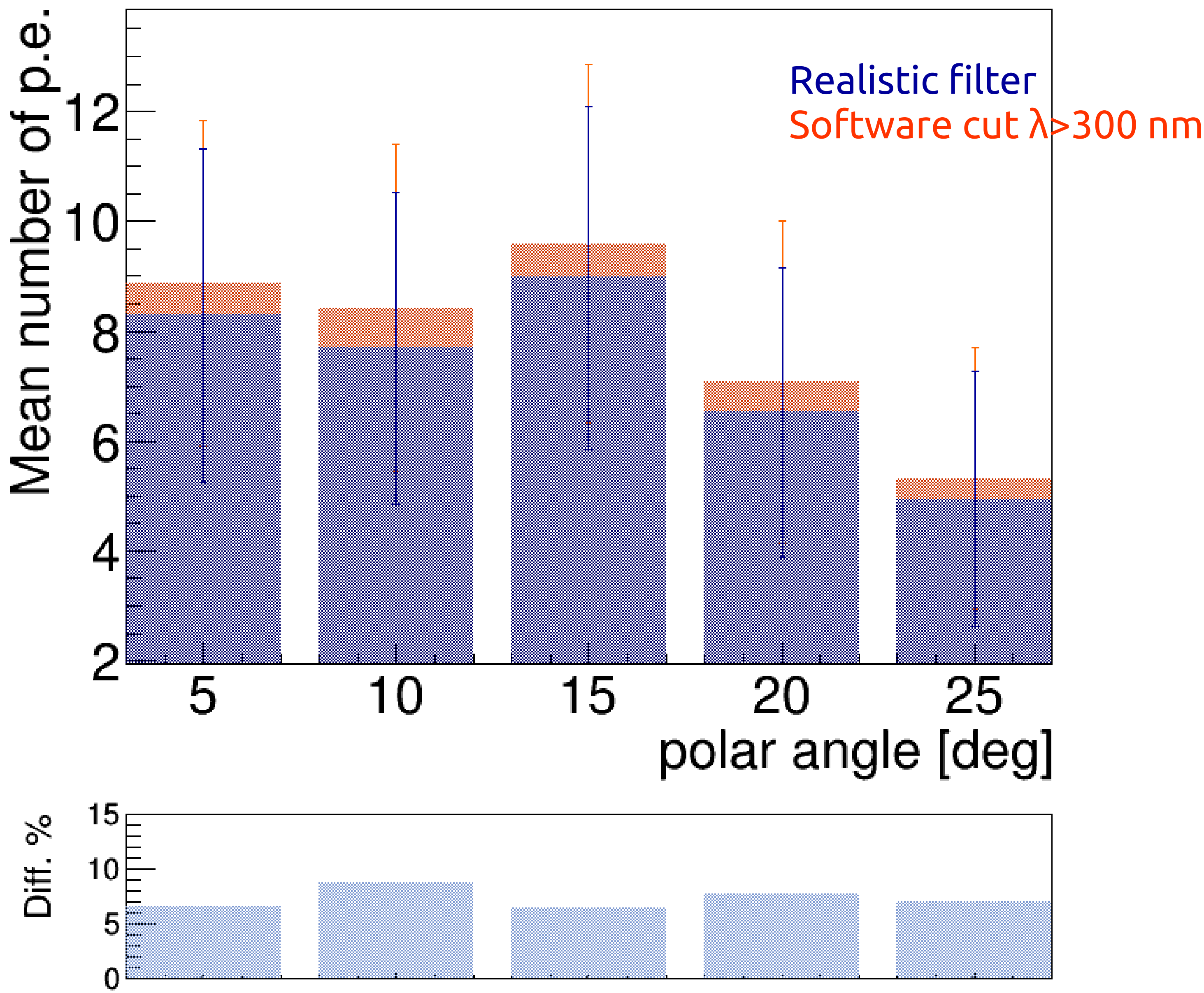




$$\lim_{\beta \to 1} N_{ph} = C \cdot L \cdot \epsilon(\lambda) \cdot \frac{n^2 - 1}{n^2} \propto \frac{n^2 - 1}{n^2}$$

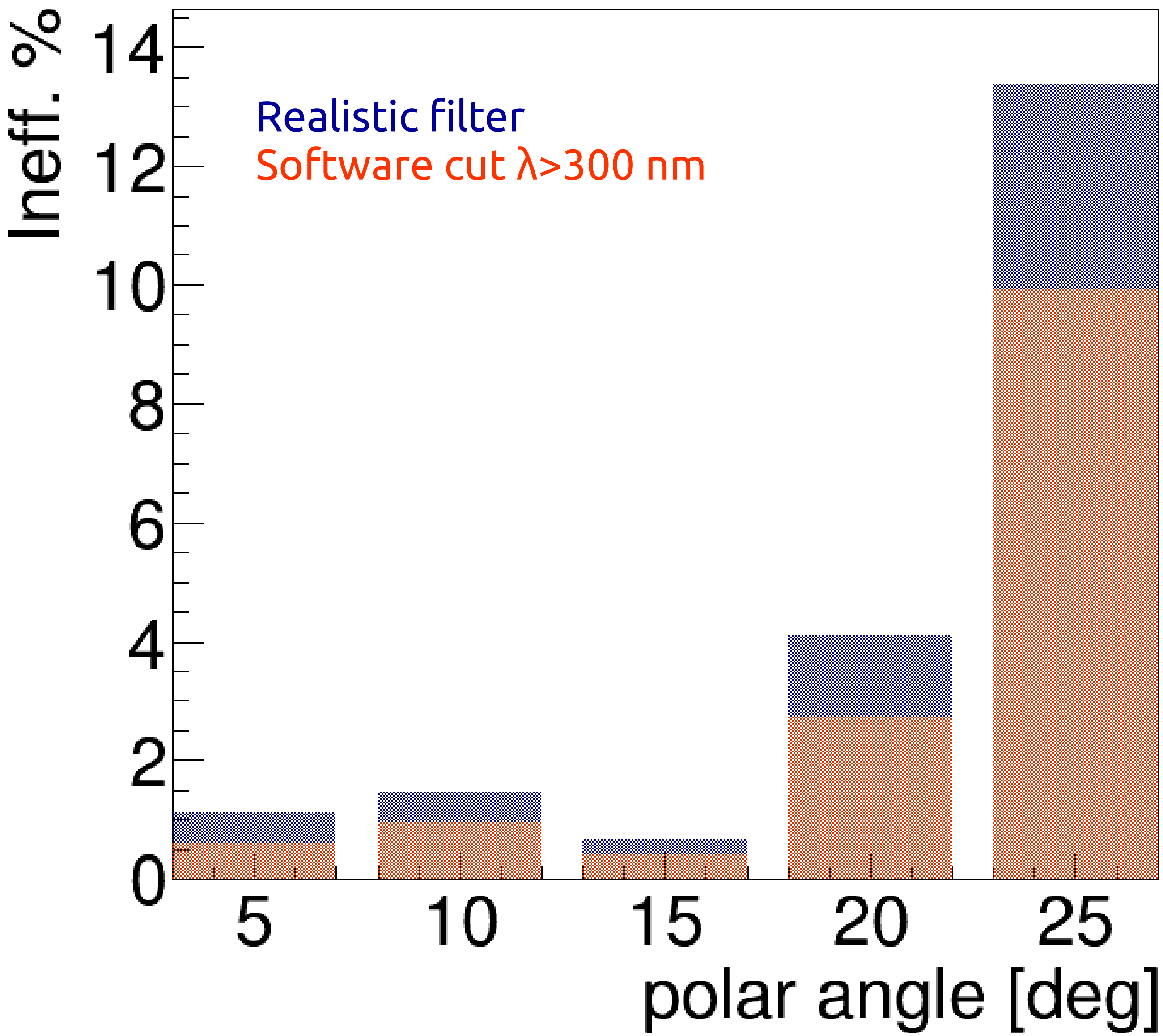
- The above distributions are resized by 0.7*Npe, assuming the same normalization of CF_4. To be validated with a prototype.

Aerogel (4 cm) N_{pe} vs polar angle



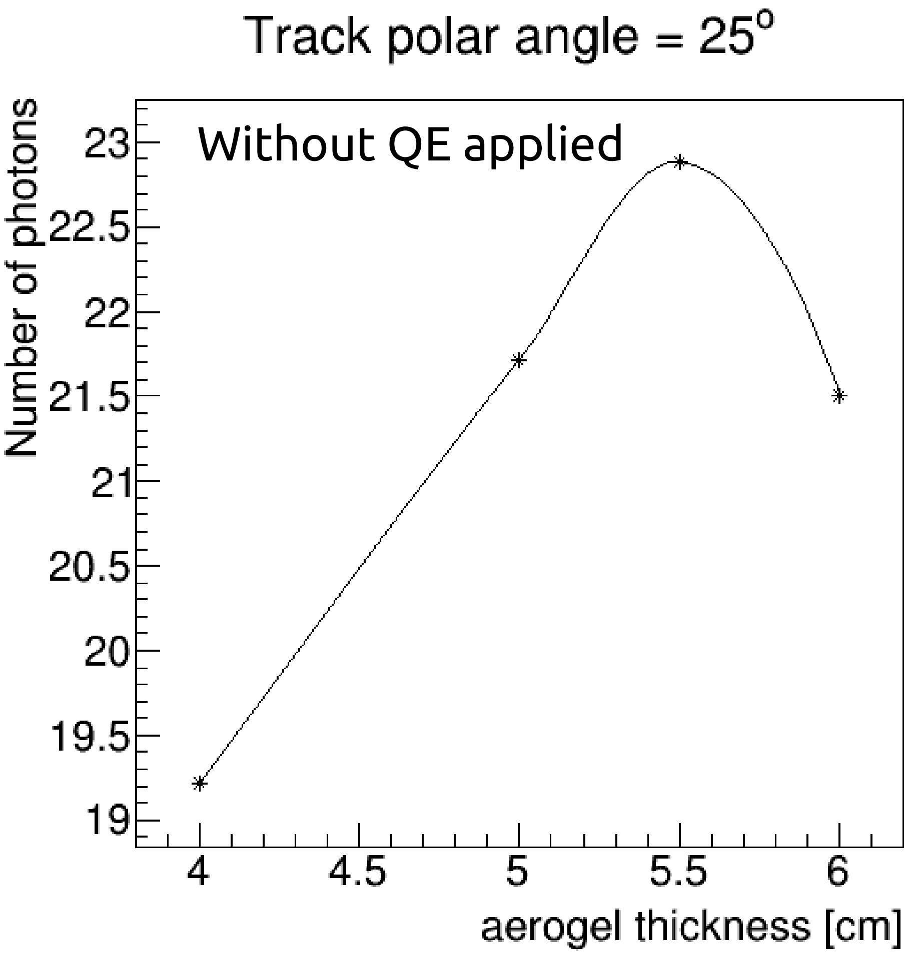
Inefficiency vs polar angle

$$P(N_{ph} < 3) = \exp(-\langle N_{ph}\rangle)(1 + \langle N_{ph}\rangle + \langle N_{ph}\rangle^2/2)$$

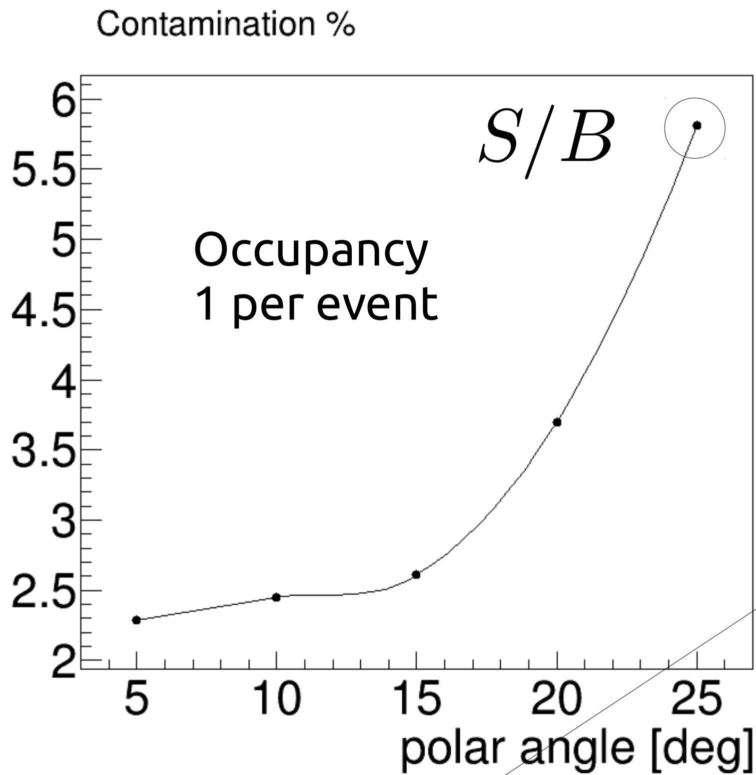


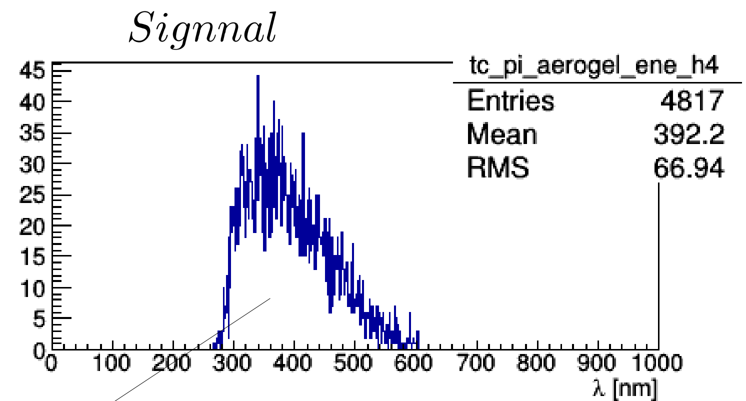
Aerogel – thickness vs number of photons

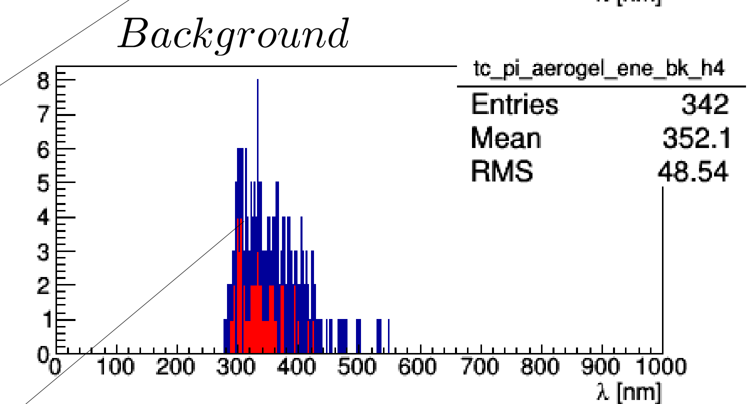
- Our baseline is 4 cm
- Aerogel can be extended to 5 cm thickness to gain some photon at high angles
- Aerogel blocks are usually provided in blocks 2 or 3 cm thick

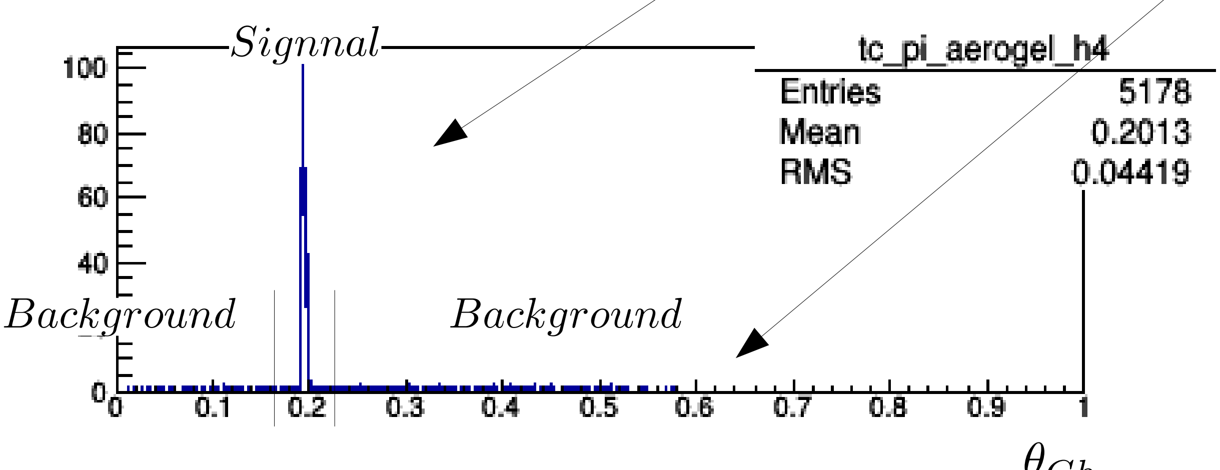


On the background with the shield









Selection cut

A question were asked during the Pawel's presentation.

The background can be eliminated with a selection cut!
To be validated in a prototype!

On the gas procurement

- The company is in Pennsylvania
- I have requested a quote for the gas in view of the dRICH prototype

CF4 specification sheet

TETRAFLUOROMETHANE/HALOCARBON 14 (CF4): A colorless, non-flammable, non-corosive gas.

Purity: Specifications:	Grade 4.0 99.99%	Grade 4.5 99.995%	Grade 5.0 99.999%
Nitrogen	< 60 ppmv	< 30 ppmv	< 5 ppmv
Oxygen	< 20 ppmv	< 5 ppmv	< 1 ppmv
Carbon Monoxide	< 5 ppmv	< 1 ppmv	< 0.5 ppmv
Carbon Dioxide	< 5 ppmv	< 1 ppmv	< 0.5 ppmv
Moisture	< 5 ppmv	< 5 ppmv	< 2 ppmv
Halocarbon 116			< 1 ppmv
Other Halocarbons	< 5 ppmv	< 5 ppmv	
Sulfur Hexafluoride			
Hydrocarbons		< 1 ppmv	
Acidity (HF)	< 0.1 ppm/w	< 0.1 ppm/w	< 0.1 ppm/w

***Moisture level guaranteed only when Electronic Fluorocarbons prepares the cylinders.*
All concentrations are on a mol/mol basis unless otherwise stated.
Product sold on the basis of total impurities. Individual impurities may vary slightly.

Cylinder Size	Fill Weight (lbs)
49L/Size 300	72
44L/Size 200	70
16L/Size 80	25
7L/Size 35	11

Technical Data:
Mol. Wt: 88.01
Sp. Volume: 4.39 cu.ft/lb
Pressure @ 70°F: 2000 psig
Valve Outlet: CGA 580
CGA 320

Shipping Information:
DOT Name: Tetrafluoromethane
Hazard Class: 2.2
DOT No.: UN 1982
DOT Label: Green, Non-Flammable Gas
CAS No.: 75-73-0

C2F6 specification sheet

HEXAFLUOROETHANE/HALOCARBON 116 (C2F6): A colorless, non-corosive, non-flammable liquefied gas.

Purity:	Grade 4.5	Grade 5.0
Specifications:	**99.995%**	**99.999%**
Nitrogen	< 10 ppmv	< 5 ppmv
Oxygen	< 5 ppmv	< 1 ppmv
Carbon Monoxide	< 1 ppmv	< 1 ppmv
Carbon Dioxide	< 2 ppmv	< 1 ppmv
Moisture	< 5 ppmv	< 1 ppmv
Other Organics	< 25 ppmv	< 1 ppmv
Acidity (HF)	< 0.1 ppm/w	< 0.1 ppm/w

***Moisture level guaranteed only when Electronic Fluorocarbons prepares the cylinders.*
All concentrations are on a mol/mol basis unless otherwise stated.
Product sold on the basis of total impurities. Individual impurities may vary slightly.

Cylinder Size	Fill Weight (lbs)
44L/Size 200	95
16L/Size 80	34
7L/Size 35	15

Technical Data:
Mol. Wt: 138.01
Sp. Volume: 2.8 cu.ft/lb
Pressure @ 70°F: 415 psig
Valve Outlet: CGA 660/CGA 320
DISS 716

Shipping Information:
DOT Name: Hexafluoroethane
Hazard Class: 2.2
DOT No.: UN 2193
DOT Label: Green, Non-Flammable Gas
CAS No.: 75-16-4

Budgetary quote

C2F6:

Purity 5.0

Size 200 (44 L) $2,500.00/ea

CF4:

Purity 5.0

Size 200 (44 L) $1,500.00/ea

Shipping estimate to Chicago area is $600.00 (I asked for Fermilab)

Cylinder purchase prices are $300.00/ea, or you can rent for $12/month/ea.

<u>Volume at at 293 K and 1 atm about 6000 L</u>

dRICH BNL version

Progresses are going on:

- ePHENIX (Nils Feege)

  Nils asked me some detail on the reconstruction algorithm and on the data format that the algorithm needs as an input. I provided to him some detail on both.

- BEAST (Alexander Kiselev)

  We (I, Zhiwen and Jin) had a mail corrispondence with Alex. We asked some detail in order to run the RICH in GEMC, but his feeling is that this looks like a path to nowhere, as they use a differet framework. Instead, he prefers to have the core of my **reconstruction code (library like)**. At the same time, he will work on adding aerogel to the BEAST's gas RICH and then he will wrap the librery in his tools to test the preformances.

class eic_dual_rich

```
class eic_dual_rich {

 private:

 public:

  Double_t cx=0.;
  Double_t cy=0.;
  Double_t cz=0.;
  Double_t R_mirror=0;
  Double_t refidx1=1.;
  Double_t refidx2=1.;
  LongDouble_t sx,sy,sz;  //coordinates of the photon hit on the mirror provided by IRT

  vector<Double_t> ch_vector; //vector of cherenkov angles

  Double_t ind_ray(Double_t Ex, Double_t Ey, Double_t Ez, Double_t Dx, Double_t Dy, Double_t Dz, Double_t vx, Double_t vy, Double_t vz, Int_t select_radiator=2);
ing

  void set_mirror(Double_t center_posx, Double_t center_posy, Double_t center_posz, Double_t radius); //set mirror parameters
  void set_radiator_one(Double_t mean_refraction_index1); //set index of refraction, first radiator
  void set_radiator_two(Double_t mean_refraction_index2); //set index of refraction, second radiator

  void fill_cherenkov_array(Double_t angle); //fill ch_vector
  void cut_cherenkov_array(Double_t theta_min, Double_t theta_max); //cut ch_vector
  Double_t mean_cherenkov_angle(); //mean value of ch_vector
  Double_t SD_cherenkov_angle(); //SD of ch_vector
  void clear_cherenkov_array(); //clear ch_vector

};
```

eic_dual_rich reco class provided to Alexander!

Reviewers' comments (RICH2016 proceedings)

Q1: The simulation is in both cases, mRICH and dRICH, based on GEMC. I am wondering if the same basic parameters, e.g. wavelength limits, QE, aerogel properties, etc, were used? If so, this should be stated at the beginning so that these topics do not have to repeated in each section again. Indeed, it is not clear for the mRICH which parameters were used!

Q2: Using a Fresnel lens is certainly a novel idea. However, Fresnel lenses are usually not used for imaging applications due to the fact that they break up the wavefront. In addition, the image quality is further degraded for off-axial light rays which is the case for a Cherenkov detector. Therefore, it would be important to learn, how much the momentum coverage is improved by using such a lens. Especially, since the lower image in Fig. 1 suggests a lot of scattered photons due to the sharp edges of the Fresnel lens.

Q3: What are the dimensions for the mRICH? There are no numbers given anywhere in the text!

Q4: Figure 3 is not suited to show that the detector is made of six sectors! Either drop this line or change Fig. 3.

Q5: For the dRICH, the individual contributions to the single photon Cherenkov angle resolution are shown in Fig. 4. It is not clear to me, why the emission contribution for the gas radiator shows a minimum at 10 degrees. Could you please comment on this feature?

To do next

Next steps:

- Simulation improvement:

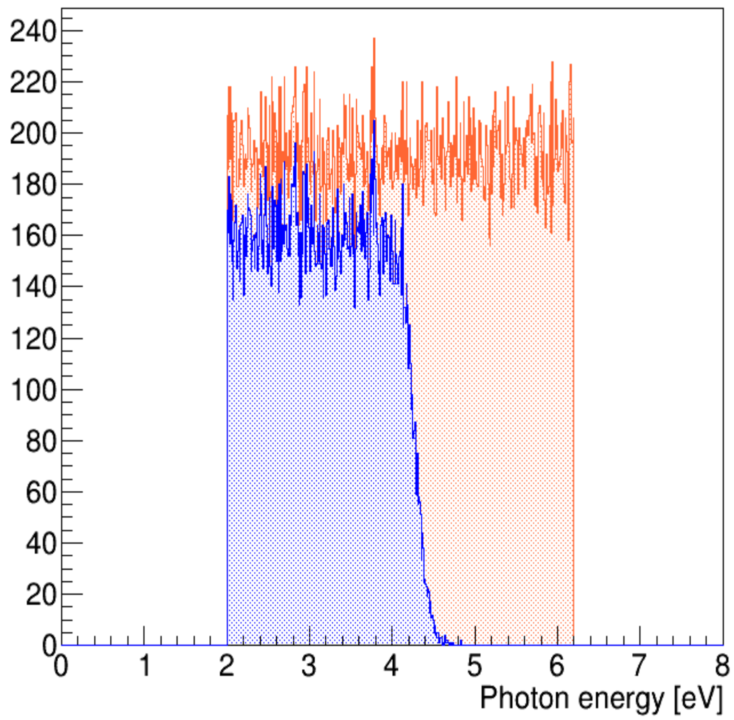
  - **photo-sensor surface shaping**

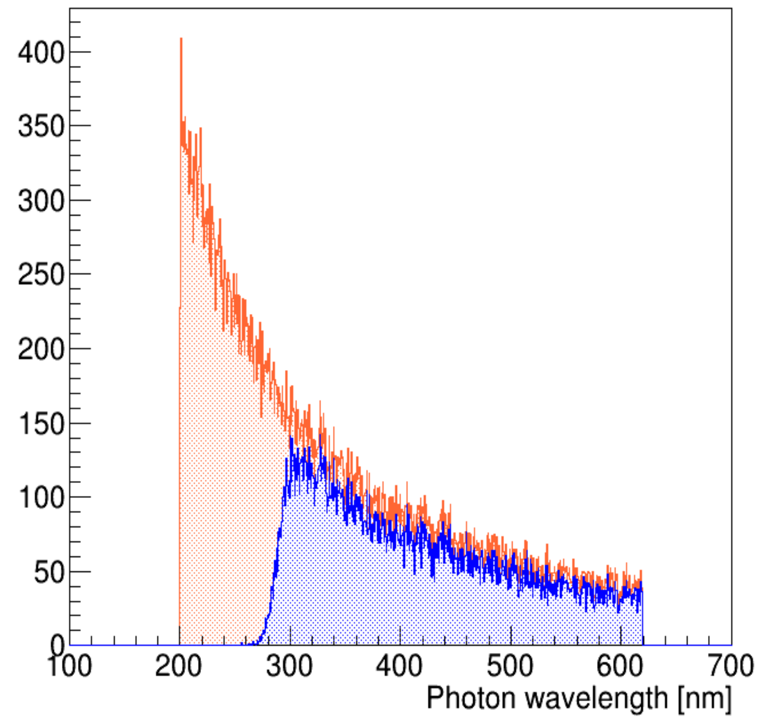
  - aerogel segmentation in blocks? (useful to test the loss of photons at the adges)

- **Response to the reviewers and the revised paper are almost ready**

Filtered spectrum

This is the effect of the shield on a beam of photons of E = [2,6.2] eV





With the shield there is an additional absorption of photons, even in the good range!
A trade off is needed!